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HISTORY OF KAW LAKE.

J. E. Todd.

EIGHTEEN years ago Mr. B. B. Smyth read a paper before the Academy, on "The Buried Moraine of the Shunganunga." In it he sketched several glacial lakes which skirted the edge of the Kansan ice sheet. Among these he outlined one which he called Kaw Lake. The writer has studied it as one of the interesting chapters in the Pleistocene history of Kansas.

DATA ASCERTAINED.

Let us first notice the significant facts so far as they have yet been recognized; then offer a theoretical explanation of them, and finally weave them into a consistent history.

1. *The Basin.*

When riding westward on the Union Pacific one loses sight of bluffs containing limestone edges on the north side, a little west of St. Marys. He fails to see any high ones again till he comes upon them abruptly at Manhattan. There he passes through a comparatively narrow gateway in a high, stony ridge which runs northward along the west side of the Big Blue and on the south swings eastward on the south side of the Kansas river.

East of the Blue the escarpment of higher hills leaves that stream four or five miles north of Manhattan and trends E. N. E. to the valley of Rock creek, and passing four or five miles north of Louisville, curves more south to the vicinity of St. Marys, as before stated. This rim rises frequently over 1,200 feet A. T. or 200 feet above the river, on the north, while on the south it rises to 1,400 feet in a few miles, particularly toward the west.

Within the limits given, no point rises more than about 1,150 feet, and while limestone ledges are seen between Wamego and St. George, they are low and are deeply covered with sand and loamy clay, especially on the west.

2. *The Configuration of the Carboniferous Bedrock Below.*

The upper limit of the Pennsylvanian shales and thin limestones lies at three levels, the lowest, underneath the channel and flood plain of the Kansas river, is from forty to sixty feet below the surface, variation being according to the inequalities of the surface and the hardness of the underlying rock.

The next level is a little higher than the flood plain near St. George, and marks the lower limit of erosion of the larger streams previous to the formation of the lake. It corresponds to the limits of such valleys. One of those valleys seems to have come south from Rock creek to St. George, another from the Big Blue northwest, and a third from the direction of Manhattan.

Mr. Oscar Talbot, who has drilled numerous wells in that region, says that the main supply of water is found in a few feet of gravel, which on the divide south of Rock creek is 160 feet below the surface. He refers the springs west of St. George, including one piped into town, to this source.

The third and highest level is between Wamego and St. George, lying east of the old Rock creek channel mentioned above. Its general height above the river south is 120 to 159 feet, with some points probably a little higher west of Wamego. Its lower portions seem to correspond to the bottom of a channel and the higher points to parts of the banks.

On the southeast flank of this higher portion, about a mile southwest of Wamego, there is a clear exposure of the second level, and at Wamego the lowest level underlies the town, while an intermediate level between the two and corresponding to a narrow silt terrace, rising 35 to 40 feet higher, is indicated by wells.

3. *Bowlders.*

Red quartzite bowlders, similar to ledges in southwestern Minnesota, with occasional bowlders of gray granite and greenstone, may be met with throughout the basin, particularly on higher points, but with the following limitations:

(1) They are more abundant in a belt one to two miles wide, extending in a S. S. E. direction from the forks of Rock creek, passing two miles west of Wamego. Along this belt they are more abundant in patches. As they rest on sand and clay, erosion has caused them to stand out on knolls in such a way as to simulate quite closely morainic hills. Further west they are less numerous, and are usually found resting on the surface of the Carboniferous bedrock. They are often deeply covered with lacustrine clay.

(2) They seem to be limited to areas below 1,150 feet A. T. This is true particularly on the south and west sides of the basin. The bluffs to the north and east of the Big Blue and north of the basin show them at much higher levels. South of the Kansas, also, bowlders are very abundant and are often of large size, in a continuation of the bowlder belt before mentioned. They rise above 1,200 feet A. T. and are sharply limited on the southwest by an old valley extending along the line of the east branch of Antelope creek and Paw Paw creek to Mill creek. West of that valley and south of the Kansas they are not found, except in the valley of Deep creek and below the old lake surface, 1,150 A. T.

(3) They are scattered in the bottom and sides of an old channel, which runs underneath the Agricultural College grounds and north to the Big Blue. There they are deeply covered with loesslike silt. They have not been found higher than the old lake level, not occurring on the hill on which the city reservoir stands. I have been informed that some have been found about nine miles southwest of Manhattan, but have been unable to verify the statement. Mr. Robert Hay states that a few were found as far west as Fort Riley.

(4) In the valley across the divide between Kansas river and Mill creek, as has already been implied, they are very abundant. The bottom of the old valley where exposed by erosion is literally paved with medium-sized bowlders, one to three feet in diameter.

(5) A somewhat similar valley nearly parallel with it, leading from Antelope to Pretty creek, a tributary of Mill creek, although 50 to 75 feet lower than the one just mentioned, has no northern bowlders in it, except toward the southern end, where it approaches the other valley. This lower valley shows signs of recent active erosion. It affords the easiest route for the railroad to traverse the high divide.

4. *Sand and Silt.*

We should speak more explicitly of the distribution of the sands and clays to which we have repeatedly referred. Between the Union Pacific railway, which follows the river, and the high bluffs which form the north rim of the old lake basin are deep deposits of sand below and a loesslike silt above. The sand is more conspicuous on the surface just west of the bowldery belt. This may be in part due to the wind raising it from the creek valleys. Some low dunes probably rise higher than the former lake level, upon the higher Carboniferous platform west of Wamego. From these elevations and the comparatively flat divide south of Rock creek the upland surface declines gently to the southwest. The bluffs bordering the river flood plain are over a hundred feet above the plain at St. George, and but little lower near the Big Blue near St. Patrick's church.

A yellow clayey silt fills the bowldery channel north of Manhattan. A similar deposit rises as a terrace north of Ogden, which may be the old delta of Seven Mile creek. Its base is sandy and its summit is 70 to 80 feet above the river.

Another deposit very similar occurs near Fort Riley. It was called loess by Robert Hay.

5. *Chert Gravels.*

These constitute a very interesting feature of eastern Kansas. Along all the streams flowing eastward from the cherty strata of the Permian there are conspicuous terraces capped with chert gravel. They are noticeable at Alma, Paxico and other similar locations. They are usually on the north side of the streams.

Such a stratum has been observed at several points in the basin of Kaw Lake. It varies in thickness and purity, and also considerably in altitude. It is found in the bottom of the ancient channel north of Manhattan, about 100 feet above the Big Blue. It is found a mile southwest of Mt. Zion church at about the same altitude.

Northeast of St. George it is about 150 feet above the river south. On the top of the Carboniferous bluffs between St. George and Wamego and extending north of the latter place, it is 100 to 120 feet above the river south. The difference in altitude may correspond to the differences in altitude between the bottom of the channel and the banks, and possibly low terraces.

South of the Kansas river it has not been found in the basin, except southwest of Wabaunsee, east of Deep creek, and about 135 feet above that stream.

In all these localities red quartzite bowlders occur, lying on the chert, but never in it.

Along Pretty creek a little outside of the basin the chert stratum has been traced at the proper level to connect with the terrace along Mill creek; moreover, it is there also sprinkled with northern bowlders.

6. *No Distinct Trace of Glacial Action.*

Another fact of significance is that no distinct trace of glacial action has yet been found in the basin of Kaw Lake. No striated ledges and no unmistakable till has been discovered. This may be explained by the supposition that deep deposit had formed before the ice sheet reached this locality. The underlying rocks were well covered. The absence of till would be accounted for by the same conditions. The ice would rest on lacustrine beds, but had little molding effect because of flotation by the waters of the lake.

ACCEPTED CONCLUSIONS.

These are the most significant facts. How may we account for them and weave the interpretation into a consistent history?

1. *The Age and Deposition of the Chert Gravels.*

As has already been hinted, the chert has every appearance of having been deposited in a river, and its derivation from the abundant cherty limestones of the Permian which cap the higher points about Manhattan and westward is quite obvious. It was evidently deposited before glaciers had come near enough to bring their contribution of northern material, for no northern erratic has yet been found intermingled with the gravel, when in its original position. Further east, near St. Marys and Topeka, where they have been rearranged at lower levels, there has been an intermingling. Still further east, northeast of Lawrence, where they are again found at an altitude of 125 to 150 feet above the Kansas, they are again distinctly separate. Their deposition must have been before the Kansas flowed through south of Manhattan, and before that channel and the one from Rock creek had been deepened as has been noted about St. George. This is attested by the old channel north of Manhattan, which shows the chert gravel, and on a level corresponding to that near Wamego. It seems, therefore, that the chert gravels may be as old as the Pliocene. It has been hoped that fossils might appear which might decide their age, but such have not yet been found.

2. *The Age and Cause of the Buried Channels West and North of St. George.*

The result of the last season's investigation has been the assurance that the channels north and west of St. George were eroded earlier than had been formerly thought. The former view had been that the somewhat lower surface west of St. George was really a terrace formed after the recession of the Kansan ice sheet, but it is now evident that the deep erosion preceded the damming of the Kansas by the ice. Stratified deposits are found to be continuous from the level of St. George up to the level of the divide separating from Rock creek. Moreover, northern bowlders are found to the bottom of the series as exposed near St. George, and well drillers report striking them down to a corresponding depth. This shows that before the lake was filled the Kansas river had cut down the bottom of its channel to within 20 or 30 feet of the present surface of that stream, or within 60 to 80 feet of the bottom of the alluvium in the trough of the present stream. From this it may reasonably be inferred that the drainage level had been lowered 70 or 80 feet from the time of the chert gravels, or about half way from the latter to the present level.

Of course this new view will require a rearrangement of conclusions all along the line. If the general drainage level had been lowered at St. George there must have been a corresponding lowering at Topeka, Lawrence and Kansas City. The erosion underneath the terrace at Cameron's bluff and Lawrence would have been before the maximum advance of the Kansan ice, not after it. And the occurrence of bowlder clay low down at Kansas City, Kan., is easily explained, which in the earlier view had been quite a puzzle.

The channel north of Manhattan was not cut down because the Kansas had broken through eastward, south of that place. The chert gravel was also left intact at other points because of the lateral shifting of the streams as they cut down.

What could have been the cause of the general drainage after it had remained so long at the chert-gravel level?

It could have hardly have been due to a differential elevation of the region, for there seems to be close parallelism between the older and later drainage levels, or slopes. Possibly there has been a general elevation. In fact, it is quite probable that there has been considerable elevation since the ice retreated, and it may have begun before the ice advanced. Possibly some of the down-cutting may have preceded the influence of the ice, but the more plausible explanation of the facts may be ascribed to the flooding of streams from the melting of the ice sheet as it advanced from the north. The first to enter the basin of Kaw Lake, we figure, was from the Big Blue, and when the ice front had reached Pawnee county, Nebraska, or later, the northern part of Nemaha county, Kansas, Rock creek would have begun its share of the work when the ice had reached northern Pottawatomie county, twenty-five miles away. It may be that Vermilion river may have come into the basin and begun similar work at a considerable earlier date, but we have no evidence of it. Meanwhile tributaries of the Kansas further east would have caused similar erosion of the trough of Kansas river further east, in its lower course, so that before the ice had reached its valley we may believe that the down-cutting may have been going on quite rapidly. Velocity of the ice and rapidity of melting would have accelerated erosion, and the length of time it took for the ice to advance from the divide to the channel of the river would determine the amount of excavation.

3. *The Formation of Kaw Lake.*

We do not know the rate at which the ice advanced nor what fluctuations it experienced, but we have found no trace of its edge pausing anywhere long enough to form a distinct moraine, or rows of drumlins.

We judge, from the distribution of bowlders, that when at the maximum extent the edge of the ice lay from the junction of Camp and Rock creeks southeast across the river and over the divide south into the valley of Mill creek, and thence eastward, with its southern edge five to ten miles south of the river, and recrossing to the north side near Lecompton.

The evidence for this is the abundance of bowlders scattered north of that line on higher points, and traces of bowlder-strewn channels leading away south of that line, according to topography. It has not been fully explored, only from Lawrence to Dover, and from Paxico to McFarland.

The Kansas valley was not so deep as now, by 75 or 80 feet. We can imagine that the river struggled with the ice for the possession of its channel, probably forming rapids and eroding actively its southern bank; perhaps for a time melting tunnels under the ice for some distance. But eventually the ice held undisputed possession and the river was completely dammed, and the water above the ice steadily rose, and we may believe quite rapidly, for the drainage of the whole western edge of the ice contributed to it.

4. *Why the Outlet Was by Paw Paw Creek Rather Than by Pretty Creek.*

Comparing the successive courses of the Kansas, it will be seen that on the whole there has been a steady shifting of the stream toward the south, hence the south side of the old lake basin was considerably further north. This is attested by the absence of bowlders south of the river remote from the ice, except in the old valley of Deep creek. This means that the valley occupied by the railroad, and lower than the old outlet by more than 50 feet, is the work of more recent erosion. A study of the junction of Antelope creek with its tributary from the southeast, near Pavilion station, favors the conclusion that the upper portion of Antelope creek formerly belonged to Pretty creek, and that a divide separated it from the valley of the Kansas. This divide was high enough in the time of Kaw Lake to prevent any escape of water except by the Paw Paw outlet. It should be remembered in this connection that below the limestones, which rise one above another to the west and southwest of the basin, there lies 300 feet of shales, which permit of rapid erosion.

5. *The Filling of the Lake.*

The lacustrine deposits of the lake came mainly from the ice sheet, which both formed the lake and furnished it sediment. When the lake first overflowed and the ice was at its maximum, the latter was probably several hundred feet thick in the river valley. It probably shed small bergs occasionally, carrying debris, including bowlders. Vigorous streams from under the ice doubtless brought much sand and silt. The larger of these, Rock and Camp creeks, brought material from the ice further north. The Big Blue doubtless brought a generous contribution from still further north. The edge of the ice is known to have lain about Blaine some 300 feet higher than the level of the lake; therefore, there were rapid streams bringing much to the Blue, not only from the northern part of this state, but from Nebraska, and possibly from Dakota, for at that time we may suppose that the surplus drainage of all the western edge of the ice sheet and of the eastern slope of the Rockies may have come through the Big Blue. We can believe that it built up quite a delta where it entered the lake, which has since been mainly removed. The filling of the channel north of Manhattan may be considered a portion of it which has been preserved by its position.

The lacustrine deposits are coarser below, even carrying pebbles and a few bowlders near the bottom, but fine silt resembling loess above. The sand is thicker toward the east, and some of it whipped out of stream channels covers much of the surface, including the highest points northeast of St. George. Further west the surface is more clayey.

6. *The Reopening of the Kansas Channel.*

Little need be said of this. The melting of the ice, as the Kansan glacier finally withdrew, probably left the channel much as it was when the ice came. The ice did not last long enough, probably, to bring much till into it. Thus far, at least, none has been discovered, though it is not improbable that some may be found in time. It is probable that when the Kansas first retraced its old course that it lowered the level of Kaw Lake quite rapidly; that the stream was rapid and vigorous and loaded with coarse material from the adjacent ice sheet. As the amount of water declined there was a stage of rapid aggradation which filled the valley lower down. The thick river deposits in the terrace northwest of Lawrence, back of Cameron's bluff, may be referred to this stage.

7. *The Formation of the Lower River Terrace.*

Reference has been made to a silt-capped terrace west and north of Wamego. It doubtless was formed since the draining of the lake and marks a stage in the history of the river since its reopening. Wells show that the bedrock underneath is not as deep as under the present flood plain. Trace of the same terrace may be seen south of the river below Antelope creek, and above and below Wells creek. Without doubt, study will find out other fragments of it, and it may possibly be correlated with the terrace at Kansas City, which is there over 100 feet above the river. Here it is only 40 to 60 feet higher.

SKETCH OF THE HISTORY.

The history may be briefly summed up as follows:

In the late Tertiary the Kansas river followed a course approximating that shown in map 2. Its volume and gradient may have been less than now.

Following that was the initiation of the continental ice sheet, with a probable gradual elevation of the western Great Plains. In the long interval in which the ice was accumulating in the north and advancing enough to affect this region directly, there may have been an increase of precipitation here which would have quickened stream erosion.

In time the ice began to creep over the northeastern divide. The Big Blue and the Kansas below their junction had their volume materially increased. Later Rock and Camp creeks were also swollen, and together they deepened and broadened the channels in map 3.

This stage was finally ended by the damming of the river by the ice and the filling of Kaw Lake as shown in map 4. The lake may have lasted a few hundred years.

The streams already mentioned, with increased vigor, built up deltas in the lake, while streams directly from the ice contributed perhaps even more. Small icebergs from the glacier, helped somewhat by river ice, scattered bowlders over most of the lake. Their numbers would be inversely as the distance from the edge of the ice sheet.

The bowlders lining the outlet may have come, a very few of them, from the lake, but most of them from the edge of the ice close along its northeastern side.

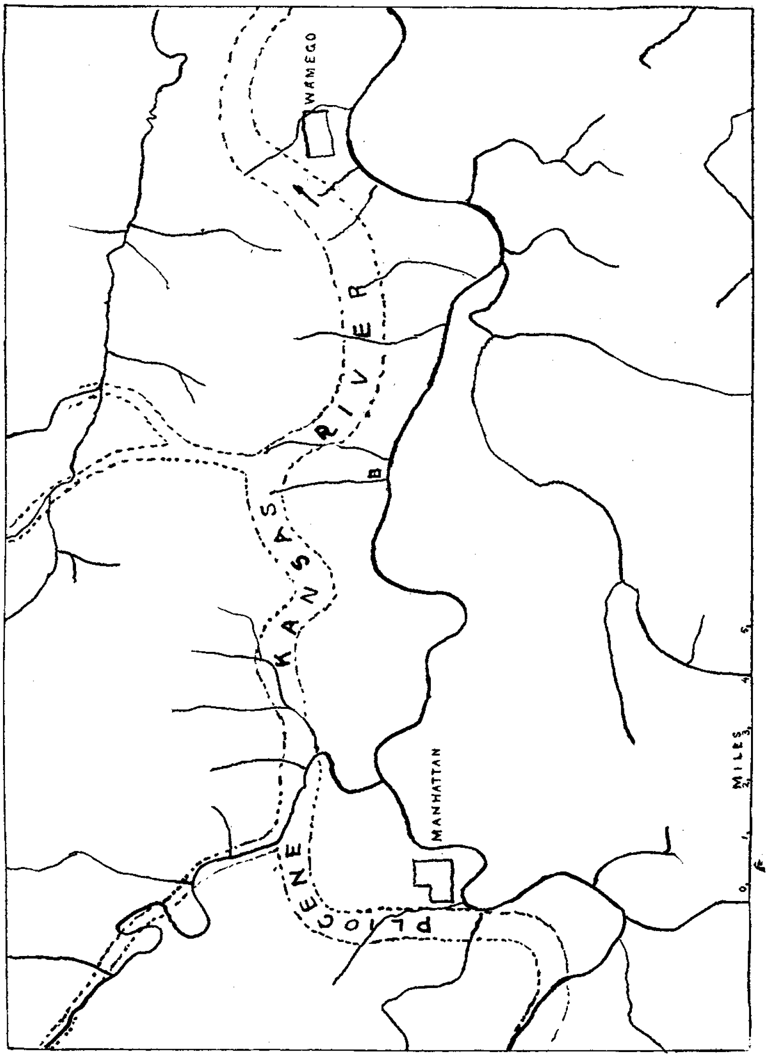
When, by the retirement of the ice, the lake disappeared, the river found its former channel much the same as before, and itself for a time much larger.

As the ice receded and dwindled the streams diminished to their present proportions and gradually cut down to their present level.

The terrace may mark a flooded stage corresponding to the close of the Wisconsin stage of the ice age.

UNIVERSITY OF KANSAS, LAWRENCE.

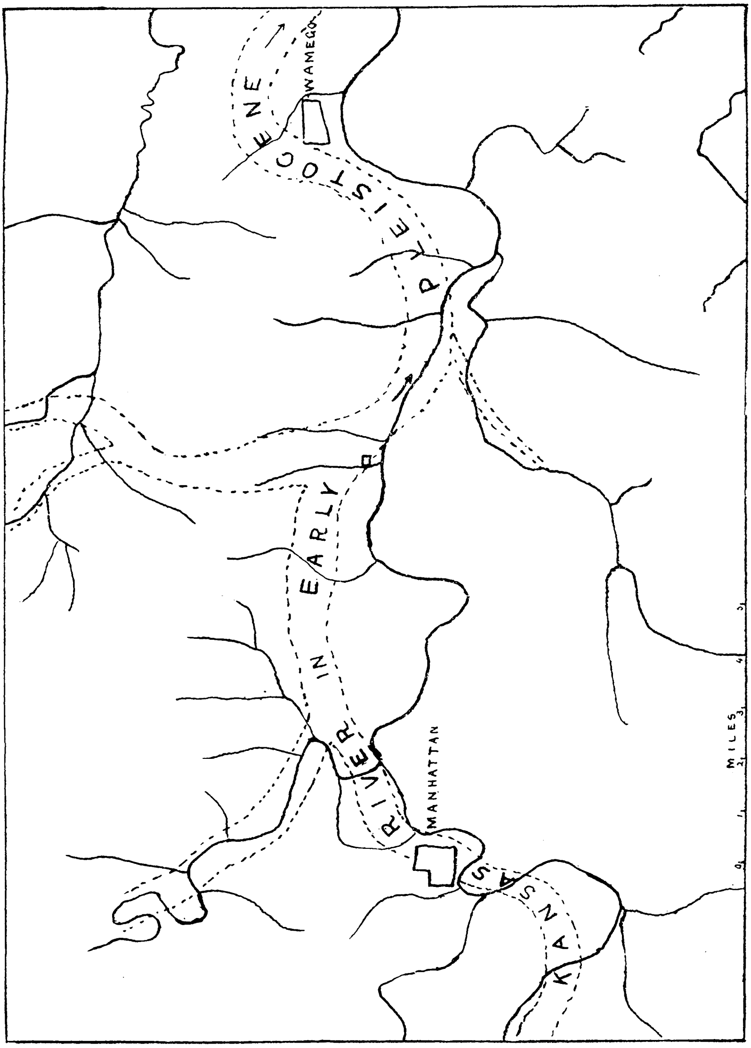
MAP 2.



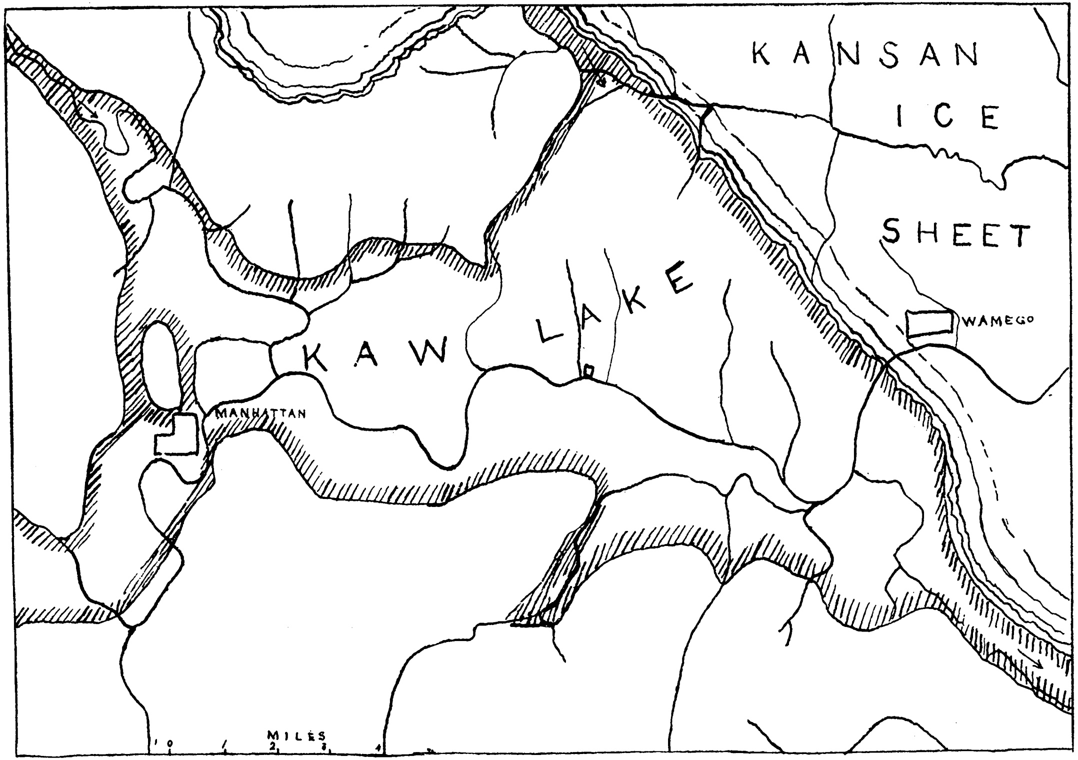
Pliocene course of Kansas river.

Trans. Kansas Acad. Sci., Vol. 28.

Map 3.



Early Pleistocene course of the Kansas river.



Maximum of the Kansas ice sheet, Pleistocene.